NATIONAL MARINE FISHERIES SERVICE INSTRUCTION 04-105-03
NOVEMBER 3, 2003

Science and Technology
Standards and Protocols for Surveys

NOAA FISHERIES PROTOCOLS FOR MID-WATER PELAGIC TRAWL SURVEYS

NOTICE: This publication is available at: http://www.nmfs.noaa.gov/directives/.

OPR: F/ST **Certified by:** F/ST (W. Fox)
Type of Issuance: Renewal (01/06)

SUMMARY OF REVISIONS:

Signed ___________________________________
[Approving Authority name] Date
[Approving Authority title]

NOAA Protocols for Mid-Water Pelagic Trawl Surveys

November 3, 2003

Prepared by:
Members of NOAA Fisheries Science Centers

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

Table of Contents

Introduction

A National Trawl Survey Standardization Workshop was convened 13-15 November 2002 with the directive to "review current protocols and directives regarding trawl survey operation, determine what changes are needed, and publish a new protocol." The objective of this effort was "to ensure that all aspects of preparation for trawl survey and trawl survey procedures are consistent and in keeping with the highest quality standards to provide for survey data accuracy and consistency from one survey to the next." At the original meeting it was recognized that a variety of surveys and gears were used in the regions, but in the interests of time, the scope of the workshop was limited to trawl surveys using twin warps. A later mandate expanded the development of national protocols to all types of surveys and all gears from which data collected were used for stock assessment. This document has been prepared in response to the latest mandate and deals with pelagic trawling survey protocol. Of all the regions, only the SWFSC conducts annual mid-water, pelagic trawl surveys used primarily for stock assessment.

The protocols contained in this document closely follow, and are often identical to, those listed in the original "NOAA Protocols for Groundfish Bottom Trawl Surveys of the Nation's Fishery Resources." Rather than drafting slightly different protocols to address very similar problems, we decided for clarity purposes to use protocols already drafted as a standard for groundfish trawling. Regional differences in procedures or protocols are identified in the Appendices.

NOAA Fisheries Mid-Water Pelagic Trawl Survey Protocols

Length measurement of trawl warps

Problem Statement

For trawls using two warps (cables), it is important to ensure that each warp is measured correctly and that marks on each warp are equidistant from the cable end. Marks on the warps are used while setting the nets to determine the correct scope, and more importantly, to ensure that the doors are equal distances behind the vessel. If measurements are incorrect, one door could be ahead of the other resulting in a skewed configuration of the net and inefficiency of the trawl.

Current NOAA Fisheries procedures for measurement of trawl warp involve periodic measurement and marking of warps at fixed increments prior to a cruise. As a secondary check of the measurements, surveys include some real-time measuring device that verifies the amount of cable deployed. If the measured cable out and the static measurements do not match, it is often difficult to decide which measurement is correct. Differential warp length can result from improper measurement before the survey begins, from stretching of the cable or cables during trawling, or from inaccuracy and slippage of metering devices. To protect against measurement errors, the proposed protocol uses redundant measuring systems to detect differences in warp length.

The protocols for pelagic trawl surveys are identical to those proposed for NOAA trawl surveys for groundfish. The importance of accurate warp measurements is obvious because mid-water trawls use a two warp system.

Protocol 1

For two warp trawling systems, two independently-calibrated measuring methods or devices shall be used on each warp, one of which will measure the warp in real time.

If the difference between the two measured distances, summed over both warps, becomes greater than 4% (or another value specified by each program and justified by independent research) of the door-to-door cable distance (i.e., sum of bridle length s and the footrope), operations must be suspended until a cause is found and resolved.

When chartering vessels for survey, programs will clearly specify and verify use of the same wire type and size consistently among vessels and years.

Specification of the warp measurement system used on each survey will be included in an Operations Plan provided by the Science Center to the officers and crew of the survey vessel.

Protocol 1a: Physical warp markings

Physical marking of trawl warps generally involves spooling the wires off the drums and onto a flat surface to measure the wire relative to standard lengths. The NOAA standard for such measurements will be that both port and starboard wires will be measured and marked side-by-side to assure that the relative warp measurements between wires are exact. The spacing of such marks, details of marking method (fiber marks interwoven in wire rope strands or painting of marks), and degree of tension on the wires will be specific to the application. These marks will be checked and re-calibrated at least annually and rechecked after a survey or whenever irreconcilable discrepancies between warp marks and the redundant measurement system persist.

Protocol 1b: In-line wire meters

In-line wire meters measure wire lengths directly using running line tensiometers or instrumented blocks over which the warp travels as it is payed out or retrieved. Such systems deflect the running wire by a known amount to facilitate measuring under tension and may be subject to deviations from true measurements due to wire slippage. These devices should be calibrated using known lengths of wire at least annually, using manufacturer recommended procedures, with moving parts (bushings, sheaves, etc.) inspected and replaced, as required. Since some in-line meters are relatively small and portable, they may be provided to the vessels by the Science Centers provided they are appropriately calibrated.

Protocol 1c: Block wire counters

Block wire counters measure the length of wire passing over a trawl block or another wheel of known circumference, which is equipped with a proximity counter to enumerate the number of revolutions of the sheave. Length of the wire is thus calculated by multiplying the number of block revolutions by the circumference of the sheave. These devices may be subject to deviations from true measurements due to wire slippage. Block counters should be calibrated at least annually with a known length of wire after assuring the proper functioning of the proximity counter and measuring sheave.

Protocol 1d: Geometric Wire Counters

Geometric wire counters (used as stand-alone wire measuring method or as a component of autotrawl systems) utilize the number of winch turns, diameter and width of the winch drum, diameter of wire and other parameters to compute the absolute amount of wire off each winch. These systems may lose calibration if the wire diameter decreases due to stretch or if the wires do not wrap properly on the winches. The counter can be re-calibrated by using a known length of wire wrapped on the winches. These calibrations should be performed at least annually, or more frequently if there are changes in wire diameter or the performance of wire wrapping on the winches.

Discussion

This protocol requires at least two independent measurements of trawl warps and establishes a tolerance level of 4% difference in measurements. This is a general guideline, and specific research on the effects of offsets on trawl performance may document different critical offset distances.

Survey operational procedures

Problem Statement

Standardization of procedures, gear, and protocol is necessary to maintain survey consistency over time. Any number of factors such as tow speed, tow duration, net size, net type, sea state, tow distance, etc., can have large effects on gear performance and catchability of species. Written unambiguous protocols addressing these factors ensure that scientists and crew maintain continuity in procedures as personnel and vessels change over time.

Protocol 2

Each Science Center will provide a written Operations Plan to their staff and the crew of the survey vessels that provides clear and unambiguous definitions of all procedures required to properly conduct trawl sampling. The Operations Plan will be discussed by the Chief Scientist and the vessel crew at the start of each survey and again when crew changes occur. The Operations Plan may include, but is not limited to, the following issues:

a. Scope ratio
b. Speed of tow
c. Duration or distance of a tow
d. Direction of tow
e. Location of sampling sites, and procedures to use if stations are not suitable for towing.
f. Criteria for determining the success of a tow and procedures to use if a tow were unsuccessful.
g. Vessels and winch operation during trawl deployment and retrieval.
h. Methodology for warp measurement and verification.
i. Trawl construction plans, at-sea repair instructions and repair verification check-list.
j. Defining responsibility (i.e. Survey scientists or vessel crew) for decisions regarding various aspects of the operations.

Discussion

All NOAA Fishery trawl surveys provide some form of an operations plan to their staff and the officers and crew of the survey vessels. Unfortunately, some of these plans can be general in nature and may not provide sufficient detail to avoid individual interpretation. Also, these plans may not be regularly updated, and any changes in procedures may not be adequately documented. By increasing the level of detail and formalizing the communication of procedures, we should make operations more consistent among members of the scientific staff and vessel crew, and the surveys operations more consistent between cruises and years.

Trawl Construction and Repair

Problem Statement

Once a specific trawl and trawl design have been selected for a survey, it is critical that this gear operates with the same efficiency every time it is deployed. The operations procedures ensure that the deployment, towing and retrieval processes are consistent over tows and years, but it is also essential that the sampling gear be standardized. Science Centers should ensure that detailed drawing of the nets, including tolerances of all materials, be available for each survey and the nets should be inspected by the Field Party Chief prior to every survey. It is also important to constantly inspect nets throughout the survey, to repair minor tears in the net, and to replace the nets when damage is significant. Because NOAA trawls are scientific sampling instruments, the protocols considered in this section are designed so that survey trawls are constructed and repaired with a level of detail needed to ensure, within specified tolerances, that the identical trawl is used at every sampling sit on every cruise.

Protocol 3

Construction plans for each survey trawl design will be maintained by each Science Center and included in an Operation Plan. The plans must include engineering drawings of the net, doors and rigging with a level of detail at least as specific as that in the ICES recommended standard (ICES C.M. 1989/B:44 Report of the Study Group on Net Drawing). In addition, each plan must contain a description of all materials used, and the qualities of these materials considered important for proper trawl function.

A check list will be developed for each trawl design specifying the dimensions, and their tolerances, or other design features considered important for proper trawl function. The check list will be used to verify that each newly constructed or repaired trawl is within operational tolerances before use.

Verification that trawls are within operational tolerances will be conducted by members of the scientific staff of each Science Center who are trained in trawl construction and repair verification.

Methodology for at-sea trawl repairs will be specified in an Operations Plan and communicated by the Chief Scientist to the crew of the vessel at the start of each cruise. A trawl repair check list will be included in the Operations Plan and used by a member of the scientific staff to verify that repaired trawls are with operational tolerances.

Appendix 1

November 3, 2003

Southwest Fisheries Science Center
Standard Operating Protocols for
Pelagic Juvenile Rockfish Recruitment Survey

Prepared by Personnel from the NOAA Fisheries
Southwest Fisheries science Center

Introduction:

Since 1983 the Groundfish Analysis Team of the NMFS Santa Cruz Lab (formerly the NMFS Tiburon Laboratory) has conducted annual juvenile rockfish surveys during late Spring (April-June) along the central California coast aboard the NOAA Ship DAVID STARR JORDAN. Midwater trawling operations are conducted during night-time hours due to potential net avoidance during daylight hours. The objective is to capture, identify, and enumerate pelagic juvenile rockfishes to develop annual abundances indices.

Protocol 1: Determination of Gear Depth

Electronic Block Counters Used for Warp Measurement:
The primary real-time measurement of trawl warps for the DAVID STARR JORDAN's two combo-winches is accomplished with electronic block wire counters, equipped with optical proximity counters, which enumerate the number of revolutions of the sheaves. The system currently in use is the "Measurement Technology" Series 200 Instrumentation Display. The system being installed in the winter of 2002-2003 will be "Measurement Technology" LC-90 Series Instrumentation Display. This is basically an upgrade. They both do the same thing in the same manner. The "Wire out" (Warp) is arrived at using a two channel quadrature proximity sensor arrangement, (it counts pulses). These sensors are arranged to supply two (2) pulses to the display/computer for every "Target" that is sensed. The sequence in which these pulses arrive at the computer determines which direction to count, up or down. The computer counts these pulses then uses the calibration constant to determine the amount of wire that has passed over the sheave. This information combined with time between pulses will give the speed.

The system keeps track of every pulse received and recalculates the wire out after every update. The trawl warp bends around the sheave before traveling up to the main deck and around the flag blocks. This system measures and displays meters of wire out and wire tension. These displayed variables can be seen in the Ship's Bridge, the aft labs, and in the winch booth. The Ship is responsible for annual calibrations of these electronic block counters.

Calibration of the DAVID STARR JORDAN's "Measurement Technology" Series 200 Instrumentation Display electronic block counter system and trawl warp.
The system currently in use is the "Measurement Technology" Series 200 Instrumentation Display. The system being installed this winter is "Measurement Technology" LC-90 Series Instrumentation Display. This is basically an upgrade. They both do the same thing in the same manner. The "Wire out" (Warp) is arrived at using a two channel quadrature proximity sensor arrangement, (it counts pulses). There are two (2) proximity sensors mounted on the cheek plate of the block. These sensors are arranged to supply two (2) pulses to the display/computer for every "Target" that is sensed. The sequence in which these pulses arrive at the computer determines which direction to count, up or down. The computer counts these pulses then uses the calibration constant to determine the amount of wire that has passed over the sheave. This information combined with time between pulses will give the speed.

The system keeps track of every pulse received and recalculates the wire out ever update. It does not simply add another meter every time enough wire has passed over the sheave. Because the system remembers the number of pulses you can change the calibration coefficient at any time, prior to using reset, and the new value for wire will be displayed.

Determining the calibration constant:
The DAVID STARR JORDAN's Chief ET previously determined mathematically, with a tape measure, the real circumference of the Ship's sheaves where the wire actually rides. You can't use anything in the specs because the actual circumference of the sheave where the wire rides is determined by the diameter of the wire and to some extent the angle of wrap. The electronic

block counter system's computer basically wants to know how many consecutive sets of pulses will be received for every meter of wire that is payed out.

Therefore, the Trawl and Combo winch sheaves are ~1.510 Meters around, where the wire rides.
So: Counts/Meter = number of targets per sheave rev * number of sheave rev per meter.
C/M = 2 * 1/1.510
C/M = 2 * 0.6622516 = 1.3245

The calibration constant should be 1.3245. Plug this number in the computer as the "Counts per Meter" entry.

Finally, the system needs to be fine tuned and the coefficients adjusted to remove the error factor caused by the Uncertainty Principle. This Uncertainty Principle and error factor are determined and adjusted for as follows:

STBD COMBO CONSTANTS	**PORT COMBO CONSTANTS**	**CENT COMBO CONSTANTS**
COUNTS PER M = 1.275	**COUNTS PER M = 1.275**	**COUNTS PER M = 1.279**
TENSION COEFS= 3000	**TENSION COEFS= 3000**	**TENSION COEF = 3000**
ANGLE COEFS = 0	**ANGLE COEFS = 0**	**ANGLE COEFS = 0**

PORT HYDRO CONSTANTS	**STBD HYDRO CONSTANTS**
COUNTS PER M = 60.01	**COUNTS PER M = 3.0**
TENSION COEFS= 4000	**TENSION COEFS= 0**
ANGLE COEFS = 36.5	**ANGLE COEFS = 36.5**

Wire out Calibration: This is very important and is easiest, and more accurate, if done while underway.

1. Use the method below to determine the beginning coefficient then verify the accuracy by spooling wire with the mechanical counter, mounted to the wire.

2. Check the sheaves of the trawl system and the wheel on the mechanical counter for ease of rotation and flag block for freedom of movement. The stiffer either is the more likely the chance you will spend your allocated time in an exercise in futility. This procedure will work if the system is properly prepared.

3. Insure you have enough water depth to avoid bottom contact.

4. Insure that you have enough weight on the line to prevent slippage on the sheave and/or the mechanical counter wheel. You can deploy wire until the weight of the wire is sufficient to accomplish this.

Do not pay the wire out at an excessive rate. Excessive speed will result in errors, due to wire slippage, and/or damage to the mechanical counter. Experience has shown that if you start at 20 M/M and increase to 50 M/M after 100M the wire tension is sufficient to prevent slippage and the counter is not stressed. Sea state also plays a part in how fast the wire can be payed out. In this case "Slower is Better".

5. Thread the wire through the blocks. The mechanical counter has been modified to allow mounting without the need to thread through the guides.

6. Secure the counter so as to allow up and down movement of the entire counter frame while avoiding excessive side to side movement. The counting wheel is spring loaded to maintain constant pressure on the wire however the less the wheel has to move the better.

7. Mark the wire with paint where it exits the mechanical counter. This gives you a reference point and might come in handy at a later date, if the paint doesn't wear off. Do not make multiple calibration marks on the cable at this time. If you blow the calibration the first time through, this just confuses the issue.

8. Payout a minimum of 500M in order to get a reasonable calibration. During payout stop at three points (100M, 250M, & 500M) to adjust the coefficient so as to cause the electronic meter indication to agree with the mechanical counter. INSURE NO SLIPPAGE OF WIRE ON EITHER COUNTER HAS OCCURRED.

9. Retrieve the wire. When your reference mark returns to where it started both counters should read zero (0). If not, be glad you didn't make multiple marks, and repeat the process until it does.

10. When you finally get a coefficient that results in getting the same amount of wire back as you deployed and the counters agree on the amount of wire out, you need to deploy one more time to confirm the system is properly calibrated.

During this deployment you could stop and mark the wire in increments that will best suit the wire usage.

Hints:
If, at the 100M stopping point, you need to increase the coefficient by a significant amount and when you get to 250M point the coefficient needs to be decreased significantly, then you have "probably" had wire slippage over the sheave during the first 100M or so. You probably should correct the problem and start over.

Probable cause(s): Insufficient cable tension during the initial 100 or so Meters.

Check: 1. Do you have enough weight?
2. Does the sheave turn freely?
3. Is the wire rubbing the sides of the Sheave groove excessively? Caused when the sheave cannot swing freely as the wire travels across the face of the drum.

Combo Winches Sheave size = 1.510 (in theory).
STBD Hydro winch Sheave size = .590 (in theory).
COMBO winches and STBD HYDRO winch:
Counts/Meter = number of targets per sheave rev x number of sheave rev/meter.
COMBO Number of targets = 2 Sheave revs/Meter = 1/sheave circumference = 1/1.510 = .6622517 Counts per M = 2 x .6622517 = 1.3245

Use the same formula for each winch.

Mechanical In-Line Wire Meter Used for Warp Measurement:
A mechanical in-line wire meter is also maintained aboard the JORDAN and is used to calibrate the electronic block counters when needed. This devise is portable and it is used as an additional independent method for measuring trawl warp. The method this tool uses to accurately measure wire rope is as follows: The wire to be measured enters through guide rollers, goes across two lower flat faced rollers, through a wire guide, and out the other side. A precision milled, flat faced, roller rides on the cable with springs supplying the tension required to avoid slipping. Excessive cable motion is compensated for by allowing some freedom of movement in the vertical direction. Motion along the cable axis (traveling) is prevented using securing lines, while motion in the cable cross axis is limited, but not prevented, by the mounting rod. The meter drive wheel is coupled to the mechanical meter through a coupled shaft, allowing the meter to be easily exchanged. The meter movement is then securely mounted to the drive wheel cheek plate housing. Thus the meter movement is directly coupled to the drive wheel. Inside the meter movement, the drive shaft is coupled to the least significant digit wheel using precision gears. The gear ratio is such that one revolution of the drive wheel advances this wheel by 1 digit. When this wheel goes from 9 to 0 the next significant digit is advanced by 1 and so on down the line to the most significant digit. The reverse happens when the wire is retrieved. Because everything is mechanically coupled there is no calibration possible. Of course you do have to trust that the manufacturer gave the proper meter movement in the first place. The meter movement units are marked on the meter. This mechanical counter is a precision measuring, mechanically coupled device that requires no calibration and little maintenance. The Ship (DAVID STARR JORDAN) is responsible for its maintenance and care.

Care of the calibrated wire counters:

On an annual basis, the wire meters will be returned to the manufacturer for refurbishment (if necessary) and re-calibration. If this is not possible and there is a concern as to the calibration of the wire counter, a field check can be accomplished in the following manner:

The counter can be calibrated using a known length of wire (at least 20 meters) measured with standard metric tape measure as follows: 1) set the 100 pound weight in the water with the ship still in the water. It would be best if this is done during calm seas to ensure that there is no wire slippage due to the ship's roll, 2) mark the wire with a piece of tape near the winch sheave, 3) measure from this mark forward, in increments, until a distance of at least 20 meters of wire has been measured, then again mark with tape, 4) attach the meter to the wire in an accessible location and secure fore and aft with rope, 5) measure the marked distance with the inline meter three times and 6) calculate a calibration coefficient from the average of the three measurements.

Protocol 2: Use of Autotrawl Systems

N/A for the SWFSC Santa Cruz Laboratory's pelagic juvenile rockfish survey.

Protocol 3: Operational Protocols for Mid-Water Trawling:

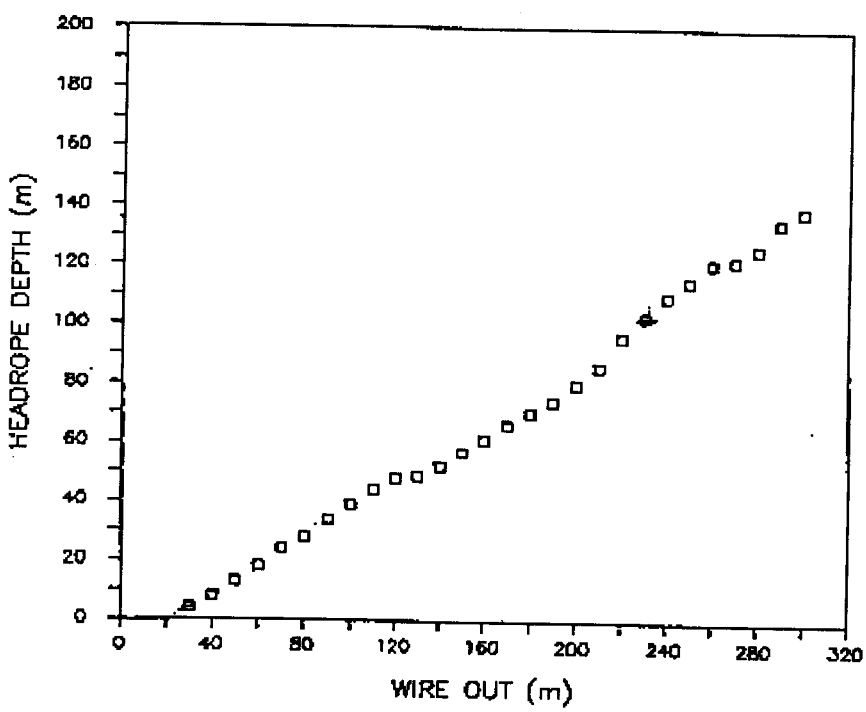
Mid-Water Trawl Station Selection:
In general, 5-7 midwater trawling operations are conducted each night between 2100-0500 PST. Standard trawl stations are sampled during three distinct "sweeps" of the survey area with all trawl stations being fished once per sweep . Each sweep lasts from 7 to 10 days/nights. A total of 21 successful nights of trawling are needed to complete the annual survey. The trawl stations remain in the same geographic locations from year to year. There are 35 standard mid-water trawl stations of fixed geographic location. Following is a list of our current trawl stations along with the geographic location for each station, the depth of the bottom at the station, the estimated trawl warp to be used for that station's tow, the station's ID number, the target headrope depth for each station, and the designated geographic Strata for each station :

Juvenile Rockfish Survey Trawl Stations

Latitude Deg Min	Longitude Deg Min	Depth(m) of Bottom	Warp (m)	Station#-Depth Identifier	Headrope Depth (m)	Geographic Strata
36% 50.8'	121% 59.0'	92	75	119-2	30	MI
36% 46.0'	121% 52.0'	73	75	114-2	30	MI
36% 44.4'	121% 58.6'	238	75	116-2	30	MI
36% 42.5'	121% 54.5'	92	75	115-2	30	MI
36% 38.5'	121% 51.5'	37	25	111-1	7	MI
36% 39.3'	121% 56.8'	73	75	112-2	30	MI
36% 35.0'	122% 10.5'	2300	25	110-1	7	MO
36% 35.0'	122% 10.5'	2300	75	110-2	30	MO
36% 35.0'	122% 10.5'	2300	215	110-3	100	MO
36% 35.0'	122% 2.0'	530	75	109-2	30	MO
36% 38.8'	122% 3.0'	915	75	113-2	30	MO
36% 42.0'	122% 6.5'	1920	75	117-2	30	MO
36% 46.4'	122% 9.0'	915	75	118-2	30	MO
36% 59.0'	122% 17.5'	82	75	123-2	30	SS
36% 59.0'	122% 22.5'	128	75	124-2	30	DS
36% 59.0'	122% 25.5'	457	75	125-2	30	DS
36% 59.0'	122% 35.5'	400	75	126-2	30	DS
36% 59.0'	122% 45.5'	1060	75	127-2	30	DS
37% 16.5'	122% 34.0'	82	75	131-2	30	SS
37% 16.5'	122% 39.0'	95	75	132-2	30	SS
37% 16.5'	122% 49.0'	165	75	133-2	30	DS
37% 16.5'	122% 59.0'	550	75	134-2	30	DS
37% 16.5'	123% 09.0'	1000	75	135-2	30	DS
37% 39.5'	123% 2.5'	120	75	152-2	30	DN
37% 39.5'	123% 12.5'	1240	75	154-2	30	DN
37% 44.6'	123% 8.3'	90	75	156-2	30	SN
37% 53.0'	123% 19.0'	90	75	160-2	30	SN
37% 53.0'	123% 30.0'	1460	75	162-2	30	DN
38% 10.0'	123% 29.0'	400	75	171-2	30	DN
38% 10.0'	123% 22.0'	183	75	170-2	30	DN
38% 10.0'	123% 17.0'	128	75	168-2	30	DN
38% 10.0'	123% 10.0'	90	75	167-2	30	SN
38% 9.5'	123% 5.0'	73	75	166-2	30	SN
38% 10.0'	123% 0.0'	55	25	165-1	30	SN
37% 47.5'	122% 52.0'	55	25	139-1	30	GF
37% 42.0'	122% 54.5'	55	25	138-1	30	GF
37% 35.8'	122% 49.9'	55	25	237-1	30	GF

NOTE: Target headrope depths and warp length are specified by the dashed number following the trawl station ID number, where the number -1 indicates a target depth of 7 meters using 25 meters of warp, number -2 indicates a target depth of 30 meters using 75 meters of warp, and number -3 indicates a target depth of 100 meters using 215 meters of warp. Example ~ Trawl Station-Depth ID “166-2" has a target headrope depth of 30 meters and 75 meters of warp will be used to fish at that depth.

Plot of relationship between amount of wire out and depth of net headrope. An RPM of 650 (2.0 knots) was held constant.



Standards for Achieving Target Headrope Depth:
Target headrope depth is a primary criterion for our trawl standardization and consistency. Target headrope depths, while trawling, are achieved and maintained by the amount of wire out for the trawl warps and a constant rate of speed through the water. All available evidence and past studies indicate that pelagic juvenile rockfishes are evenly distributed in the upper mixed layer along the central California coast. Variances of +/- 5 meters for the trawl headrope depth during deployment is not a significant issue, but we endeavor to fish as close to the target headrope depth as possible.

A Vemco TDRs (temperature-depth recorder) are attached to the trawl net headrope and footrope during each deployments. The TDRs are rated for a maximum depth of 68 meters and are housed in a PVC tube for protection and attachment hardware. The 2 Vemco TDRs provide retrospective data on headrope depth, water temperature at the headrope, footrope depth and water temperature at the footrope. The Vemco TDRs record this information every 10 seconds and each trawl produces a downloaded ASCII data file and a downloaded binary data file containing all the TDR recordings from 2100 to 0600 (local time).

In addition, starting in 2002, four SIMRAD ITI acoustic sensors (trawl-eye, depth-temp, port wing spread, starboard wing) are attached to the headrope and to the net wings (near breast lines) during deployments. The SIMRAD ITI measures the performance and geometry of trawls used during the mid-water tows in real-time. Information is displayed and recorded on headrope depth, footrope depth, distance between spread sensors, and seawater temperature at the headrope. The ITI system consists of four sensors that are clearly marked with respect to their orientation (i.e. Up, Towards Vessel, Port, and Starboard). There is the Trawl Eye, which measures head rope height and foot rope clearance; a temperature/depth combo sensor; and a pair of wing units (one master & one slave), which measures the wing spread. Together, all ITI data is automatically logged and the recordings are refreshed every 30 seconds at the highest sampling rate. The chief scientist or his/her delegate will monitor the ITI display throughout each haul, and will periodically record the values on the SIMRAD ITI Data Form. Prior to the first haul, the Trawl Eye and Depth/Temp Combo sensor are mounted in mesh bags at the center of the head rope. These units can be left attached to the net between tows. The wing units are clearly marked Port and Starboard and are attached to the wing of the net at the intersection of the bridle and the wing. During each tow, the wing spread sensors are attached at the beginning and removed upon net retrieval so that the bridle can be spooled effectively. The units are quite rugged and can stand the abuse of shooting and retrieving the trawl, but excessive and continuous rough treatment can affect their operation. The Chief Scientist is responsible for the SIMRAD ITI operations, or delegating this responsibility to another person. The wing spread sensors are recharged at the end of each night's fishing operations with the supplied battery chargers. The trawl eye and depth/temp combo sensor are recharged after 3 nights of fishing operations.

During mid-water trawl deployments (setting, fishing, retrieving), the Ship's speed is maintained at 650 RPM (approximately 2 knots, speed through the water). Speed variations of Å 0.5 knot are acceptable, but the target is 2 knots and should be adhered to as closely as possible. Monitoring and recording of tow speed will be accomplished in real time using the electronic speed log and GPS unit supplied by the Ship. Should this government provided GPS fail, the Deck Officer on watch should use the vessel instrumentation that he/she believes most closely matches that of the government unit. In such cases, the Deck Officer and Chief Scientist will document the instrumentation used to monitor tow speed.

For a target headrope depth of 30 meters we use between 75 (minimum) and 90 (maximum) meters of wire out. The exact amount of wire out for the trawl warp is determined after the first trawl of the night from examination of the TDR (1992-present) and SIMRAD ITI (2002-present) data. Heavier weather usually requires more warp. Lengths of trawl warps are not altered when the net is fishing at the target headrope depth.

Standards for Duration and Direction of Trawl Deployments:
The standard duration for fishing the trawl net at the target headrope depths has always been, and will remain, constant, at 15 minutes. In areas of high jellyfish concentrations, "test" trawl deployments will be made with a 5 minute, fishing at target depth, duration. The fishing at target headrope depth begins when the designated amount of warp is out, with winches braked. All aft deck lights will be turned off when the net is at target headrope depth so that no lights are visible when the net is fishing at depth. An acceptable standard 30 meter target depth tow normally takes 10 minutes to set and 10 minutes to retrieve, if setting or retrieving takes 20 minutes or more the tow may be repeated at the discretion of the chief scientist.

The standard tow direction is downwind with following seas dead astern. If both the wind and seas are calm then the tow direction will be towards the next trawl station. If only the wind is light, the tow direction will be downs well. In high cross currents, the course will be altered into or with the current. Maximum sea state is determined by the combination of wind and swells with the height of the seas being more significant than wind speed during the trawling operations. The Ship's Officer of the Deck, and the on watch Deck Department Chief will decide when trawling operations are no longer safe.

Standards for Recording Trawling Operations Information:
The Ship's on-watch Officer of the Deck will record all pertinent trawling operations information into the Marine Operations Log. The following specific information is to be logged either electronically or in written form during a tow:

Trawl Station Number-Depth ID
Sweep Number
Gear Type: MWT
Sequential Haul Number
Bottom Depth
Cloud Cover
Date-Time and Location When Net Goes In the Water
Date-Time and Location When Net Begins Fishing at Target Depth
Date-Time and Location When Net Haulback Begins
Date-Time and Location When Net is Back on Deck
Meters of Wire out for the Warp

In addition to the information logged on the bridge by the on-watch Officer, the Scientific Computer System (SCS) aboard the ship shall log the following:

Wind Speed
Wind Direction
Barometric Pressure
Sea Surface Temperature
Sea Surface Salinity

Standards for Handling the Trawl Net and the Catch:
The on-watch Deck Department personnel, in concert with the on-watch Officer of the Deck shall be responsible for having the Ship on station, at towing speed, operation of the trawl winches, and setting-fishing-retrieving the trawl net. When the codend is back on deck at the end of a tow the net and catch will be handled as follows:

The Deck Department personnel will retrieve and spool the bridles and entire net, then open the codend liner into containers that the scientists provide at the net reel. The codend liner will be shaken down twice by the Deck department, once on the net reel and then the entire codend is shaken down a second time on the deck. The 2 codend liner shakedowns are performed to ensure that all catch is clear of the net before the next tow. The Deck Department will ensure that the V-doors and transfer cables are secured. The codend liner will be reclosed with a cinching cowbell by the Deck Department. The catch will be carried into the aft Lab for sorting, identification, enumeration and preservation by the scientists.

Standards for Trawling Operations in Case of Problems:
When there are problems with a tow, a code number is assigned to the tow. All tows are given a numerical code based on the success, problems, or failure of the tow. The chief scientist is responsible for assigning the code number for each tow. The following are examples of problems or failures during a tow:

- The amount of time during the set and/or retrieval is too long
- unacceptable amounts of jellyfish in the catch
- gear damage or malfunction
- evidence of net contact with the bottom
- visible sunlight in the sky when tows are performed near dusk and/or dawn
- geographic position of tow to far away from the trawl station position

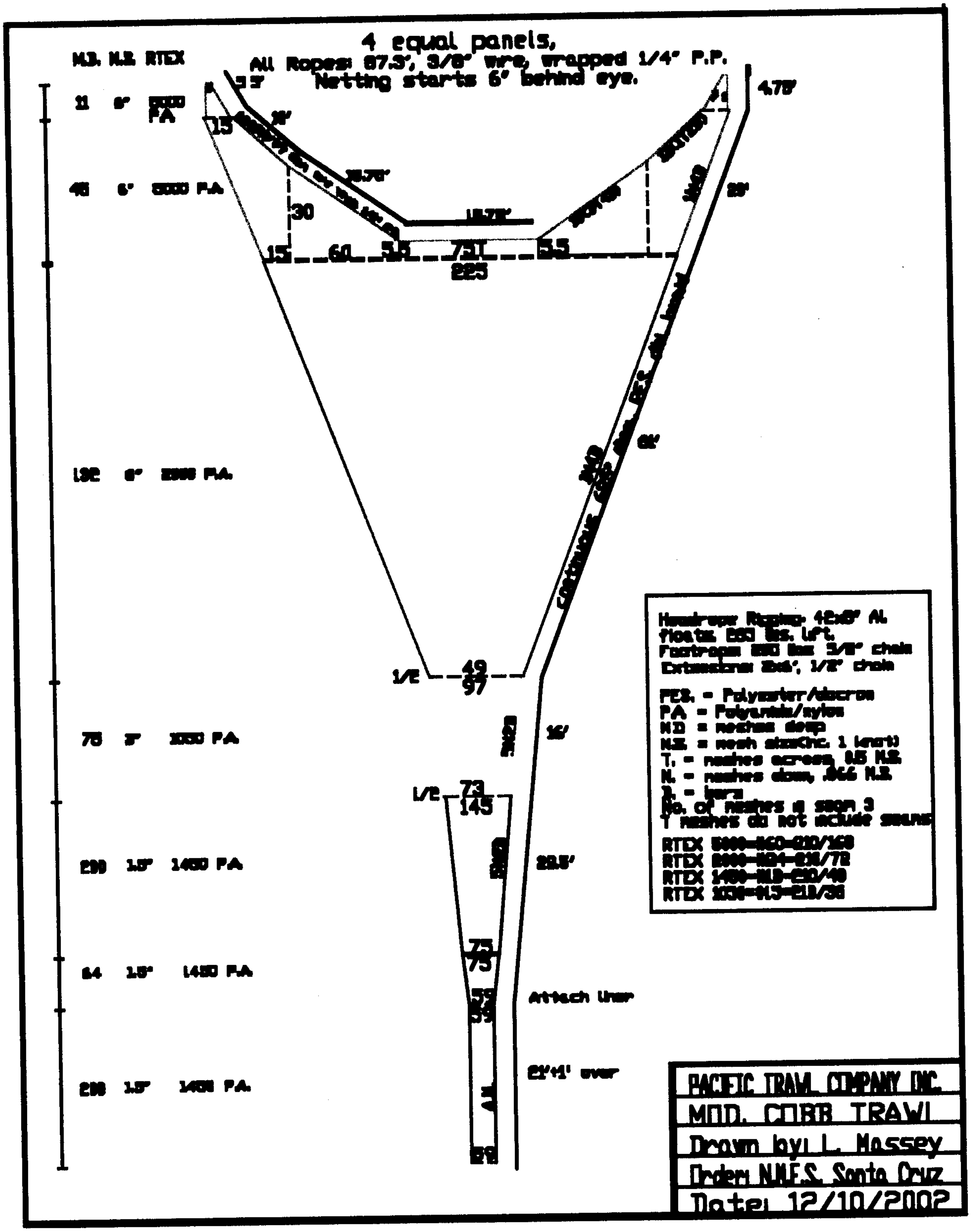
The starting position for a tow will be within one mile of the station. In rare instances, navigational constraints may not allow a mid-water trawl to occur within a one mile radius of the specific station location. These tows will be considered on a case by case basis by the scientific party to determine the appropriate disposition. Tows are repeated at the discretion of the chief scientist and on-watch Officer of the Deck based on the success of the trawl and the constraints of time, navigation, and weather.

Protocol 4: Trawl Construction and Repair:

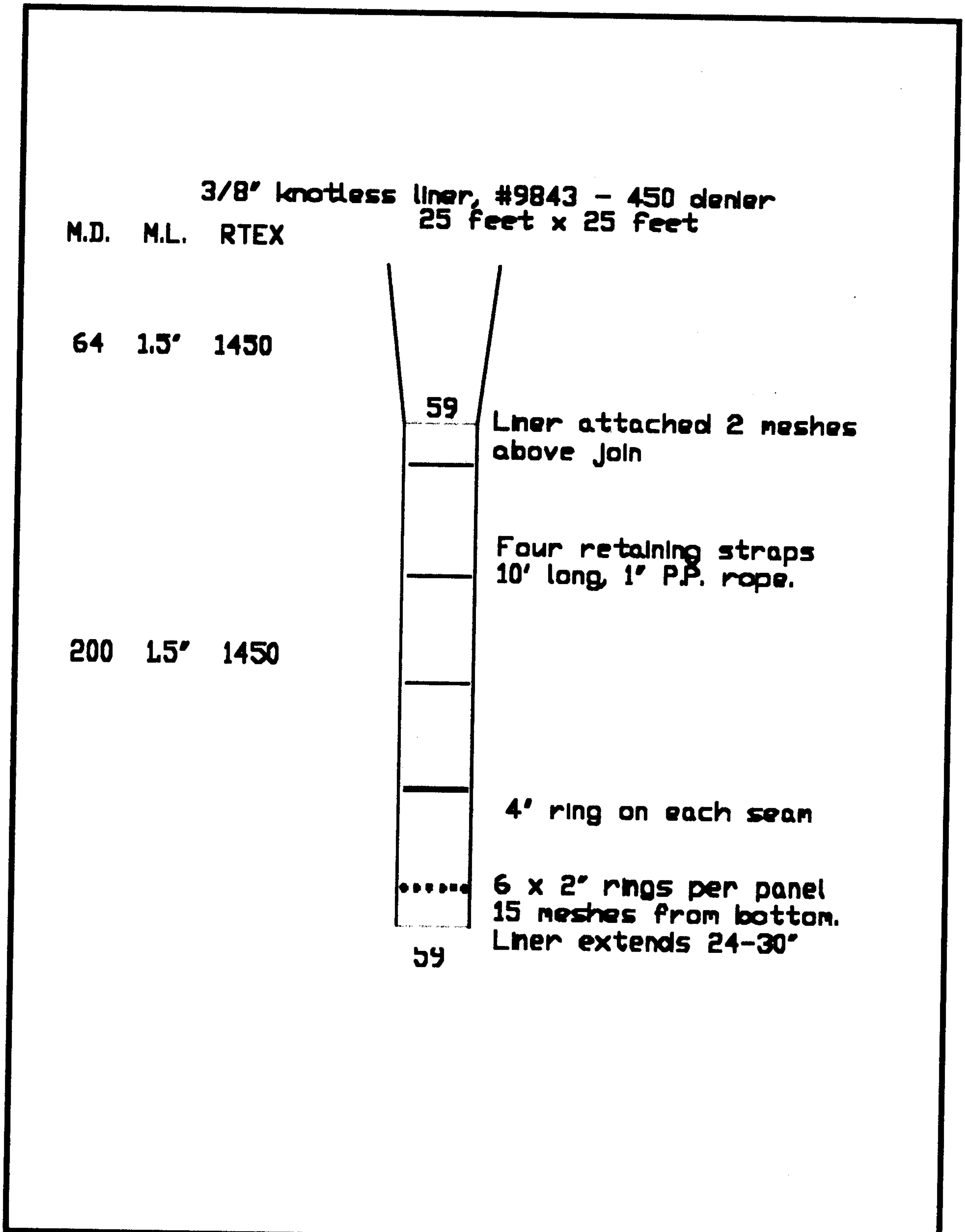
Midwater Trawl Description:

The midwater trawl net is known as the modified California Department of Fish and Game "Anchovy" Net. It is also commonly referred to a the NMFS Modified Cobb Trawl. A 3/8" (0.95 cm) fine mesh, knotless, white liner is inserted in the codend to retain small midwater organisms. The mesh liner is 25 feet (7.6 meters) wide with 7.75 feet (2.4 meters) per panel, with 4 panels. The overall length of the liner is 30' (9.5 meters). The overall length of the entire net is 154 feet (47 meters) and has a square mouth of 86 feet per side (26.2 m per side). The net is constructed of nylon webbing and the mesh size (stretched) decreases from 6 inches (15.2 cm) in the wings and body to 1.5 inches (3.8 cm) in the codend. The codend is secured by a cowbell during tows. A zipper is also sewn into the meshes above the liner in order to release large catches of jellyfish. To open the net vertically, 42 eight inch (20.3 cm) floats are attached to the headrope. 145 lbs. of 5/8" chain is attached to the bottom of each wing and along the footrope. There is a 6 foot, **1/2** inch chain, extension to the lower bridles. Total chain weight of 325 lbs. The bridles are V shaped with each section being 180 feet (55 meters) long. The doors are 5' x 7' steel V doors manufactured by Net Systems, Inc. USA. Each door weighs approximately 830 lbs. The trawl nets will last approximately 3 field seasons (3 juvenile rockfish surveys), at which time they are replaced. Older trawl nets are kept as a backup net if the newest net is damaged beyond repair during the cruise. We construct the trawl nets to the same standards each time one is built. Following are plans for the net, liner, and doors and a trawl construction materials list.

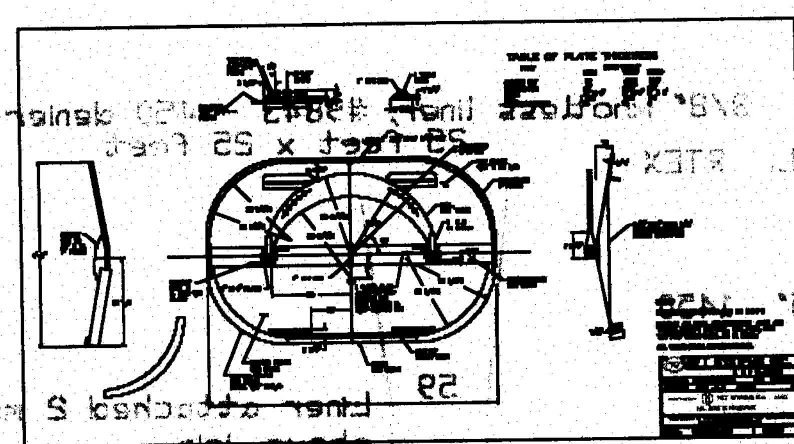
Net Plan:


4 equal panels,
Netting starts 6' behind eye.
4.75'
30
15
60
225
49
97
1/2
73
145
75
75
Attach liner
PA = Polyamide/nylon
PACIFIC TRAWL COMPANY INC.
MOD. COBB TRAWL
Drawn by: L. Massey
Order: N.M.F.S. Santa Cruz
Date: 12/10/2002

Codend Liner Plan:



Door Plan:



Mid-Water Trawl Construction Materials List:

WEBBING:
Mesh sizes listed in the net plan are given in "stretched measure", a standard method of measuring mesh size that includes the length of one knot, designated K.C.. Wings and body of trawl constructed of 6" #60T three strand nylon - dyed green.

CODEND LINER:
Liner in codend~ 3/8" #9843 - 450 denier, 25' wide by 7.75' long per panel with 4 panels connected to form cylinder. Knotless. Overall dimension is 25' wide by 30' long. White or off-white in color.

WIRE:
6 x 19 Galvanized fiber core, eyes are formed using galvanized reinforced thimbles.

ROPE:
Headrope/Footrope/Breastlines are all 3/8" wire rope.

FLOATS:
Forty-Two 8" side lug or center hole trawl floats, equally spaced along headrope, 256 lbs. static lift.

RIBLINES:

5/8" Samson@ 2n1 stable braid, Dacron, light bonding. One link of deck lashing chain is seized to the eye of the ribline and forward end (at wing tips) of ribline is equal to the length of the headrope/footrope/breastlines. Two thimbled eyes and chain link secured to the eye of the ribline, are attached to the bridles using one 5/8" hammerlock. Riblines are measured with 400 lbs. of tension on rope.

FOOTROPE:
86' of 3/8" 6 x 19 galvanized fiber core wire rope. (86' does not include the length of the thimbled eye at either end) 145 lbs. of chain is secured to the footrope along each wing tip, lashing every 6th link to the wrapped wire rope. Footrope extension of linked grade 80 deck lashing chain is connected to the footrope wing tip using a 5/8" hammer-lock. Overall length of footrope extension including hammerlock is 6 feet.

HEADROPE & BEASTLINES:
86' (not including length of thimbled eyes) of 3/8" 6 x 19 galvanized fiber core wire rope. Wire is served with 3/8" three strand polypro rope.

BRIDLES:
V shaped, 1/2" wire rope, 180' (55 meters) long, terminated with thimbled eyes.

Mid-Water Trawl Construction Materials List (continued)
DOORS:
Two 7'x5' steel V doors, each weighing approximately 830 lbs. Manufactured by Net Systems Inc. USA, Phone 800-722-5568, Web Address: http://www.net-sys.com. The Doors were designed specifically for NOAA NMFS by Gary Loverich in July of 1979, Door Serial Number is 892. Door tail chains of 13mm long link chain are attached to the center hole of the two tail chain brackets using a 5/8" safety shackle. The upper of these chains is 8.5' long, and the lower is 8.5' long. They come together into a 13mm hammerlock, to which is attached a single 13mm chain which is 31' long. This chain terminates in a 19mm G hook, joined to the chain with a 13mm hammerlock. A pendant of approximately 24 inches of 7/16" medium link chain, is attached to the inside, upper, aft bracket. At the end of this pendant, a 19mm recessed link is attached with a 13mm hammerlock.

Trawl Repair Checklist:
The Ship's Captain, Deck Department Chief and deck department personnel in collaboration with the Chief Scientist or cruise leader will address all aspects of the trawl checklist prior to the cruise, and as repairs are required to the trawl during the course of the survey. This checklist was approved by Liam Massey of Pacific Trawl Company, Inc.

COMPONENT	SPECIFICATION	PORT	STARBOARD
Bridles	180' (55m) x _ " 6x19 wire rope		
Doors	7'x5' V-door with transfer cables		
SIMRAD ITI Sensors: (Trawl Eye) (Combo temp-depth) (Port Spread) (Starboard Spread)	Batteries charged, 2 bags near center of headrope and a bag on each wing at center of breastlines.		
Net Panels	correct meshes, no tears-holes-breaches*		
Overall Net Length	47 meters (154 feet)		
Footrope	86' x 3/8" wire rope with 290lbs of 5/8" chain and two 6' 5/8" chain extensions		
Headrope	86' x 3/8" wire rope with 42 x 8" evenly spaced floats		
Codend Liner	3/8" fine mesh, clean, and attached in codend		
Riblines	5/8" Samson 2n1 stable braid with robust lashings to the webbing**		
Hammerlocks, G-Hooks, Thimbled Eyes	Robust structural integrity and lack of significant corrosion		

* Replacement netting and twine should be the same size and color. Knitted meshes should be the same size or larger, and knots pulled tight.

** Replacement ropes should be of the same material, be within 2" of specified length, and should be replaced when outer cover is damaged.